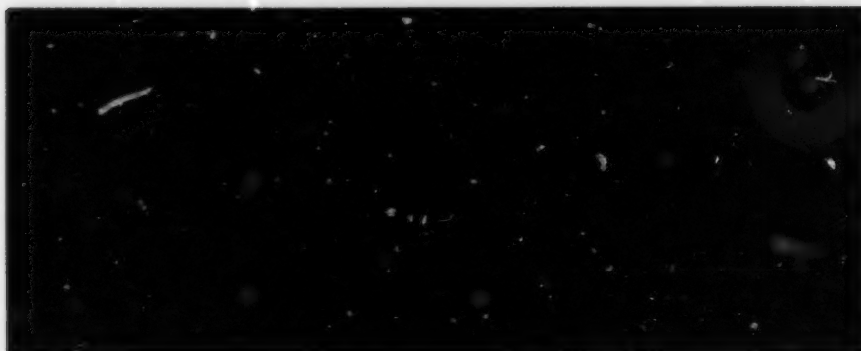


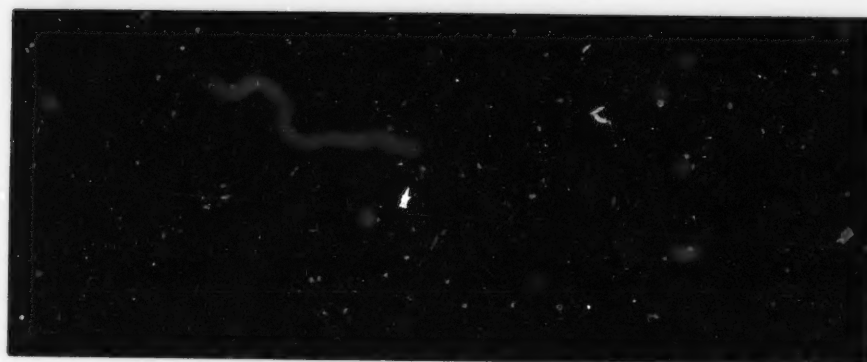
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ENZYME USE IN BARLEY RATIONS FOR POULTRY

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ENZYME USE IN BARLEY RATIONS FOR POULTRY

1. INTRODUCTION

An important emphasis of research in poultry nutrition at the University of Saskatchewan has been the encouragement of more extensive use of barley in poultry feeding. This involves development of superior barleys for feed in cooperation with barley breeders, as well as optimizing performance of poultry fed barley through various dietary manipulations. Enzyme supplementation of barley diets, in particular, produces substantial improvements in the traditional feeding value of barley. The research program involves all aspects of this subject: enzyme production, theoretical nutrition, as well as large-scale feeding trials with the cooperation of local poultry industry.

2. ENZYME-ENHANCEMENT OF THE FEEDING VALUE OF BARLEY - THEORY

1) Rationale for enzyme supplementation of barley and rye diets

Various feed additives are promoted in the market place on the basis of enzyme activity. Promotion usually centres on supplementing the endogenous enzyme output of the digestive tract should this be limiting, or providing the animal in question with enzymes necessary for utilizing dietary components otherwise unavailable, for example fibre constituents by monogastrics. Considering the low enzyme level usually added, the contribution to endogenous output with exogenous enzyme would be marginal at best. Similarly, due to the time-frame involved, it is unlikely that appreciable fibre digestion could be realized with inclusion of cellulolytic enzymes in monogastric diets.

A second group of enzymes involved in breakdown of cell-wall derived substances appear highly effective in improving barley and rye for poultry

feeds. The cell-wall constituents in barley and rye, β -glucan and pentosan respectively, are prone to solubilization upon contact with the aqueous environment of the gut, inducing a viscous condition that interferes with nutrient assimilation (Classen *et al.*, 1985; Campbell *et al.*, 1986; Edney *et al.*, 1988). Fortunately, elimination of these effects requires minimal damage to the molecules in question to disrupt their viscous character (White *et al.*, 1983). While the potential of enzyme addition to poultry diets containing barley has long been realized (Jensen *et al.*, 1957; Fry *et al.*, 1958; Willingham *et al.*, 1959; Burnett, 1966), it is only recently that similar approaches have been undertaken to improve rye as an animal feed (Patel *et al.*, 1980; Marquardt and Fengler, 1985). The destruction of pentosans in rye achieved with gamma irradiation also elicits a pronounced improvement in performance, which illustrates the potential benefits to be gained with enzyme addition (Campbell *et al.*, 1983ac).

ii) Effect of β -glucan or pentosanase on nutrient assimilation in chick diets.

Both β -glucan and pentosan are carbohydrate gums that exhibit similar physical characteristics with respect to their solubility and capacity to increase viscosity. It is not surprising that both have similar effects from a nutrition standpoint. The solubilized gums are believed to act as a barrier to diffusion of nutrients within the gut lumen, thus limiting rate and extent of nutrient absorption. Another postulated mechanism is based on the capacity of the gums in general to interact with the cross-link polysaccharides protruding from the absorptive cells lining the small intestine (Johnson and Gee, 1981). This is thought to thicken the unstirred water layer immediately adjacent to the enterocyte, which is rate-limiting in nutrient absorption.

The net effect would be the same as that described previously; and it should be emphasized that the two effects are by no means mutually exclusive.

Rye, barley, and oat groats impair nutrient absorption in chicks (Campbell *et al.*, 1983 a; Edney *et al.*, 1988) including protein, starch, and fat. Malabsorption in the case of fat is particularly severe, which may relate to particle size and restraints upon free diffusion imposed by the solubilized gums. Thus fat, which exists in the gut lumen as micelles, is a large conglomerate and constraints on diffusion are correspondingly greater than for free sugars, oligosaccharides, amino acids or peptides. One consequence of fat malabsorption relates to inadequate bone mineralization and leg problems, which appear to arise from interference with fat-soluble vitamin D absorption (Campbell *et al.*, 1983 b). The presence of unabsorbed free fatty acids may also contribute, by complexing dietary calcium and further reducing its availability for bone deposition.

Compounding the problem of uncertain nutrient availability are effects gums have on the flow rate of digesta through the gastrointestinal tract. Both rye and barley retard transit (McKay, 1980; Salih, 1986), which combined with reduced nutrient absorption will reduce total nutrient assimilation for a given time period. Furthermore, when feeding diets based on barley particularly, the nutrient density of the diet will probably be lower than that attainable with a wheat or corn diet. Obtaining acceptable results will necessitate higher consumption rates, which in turn will be limited if the birds' ability to process that food is compromised.

In addition to the direct effect of the gums, there appears to be a secondary effect attributable to higher levels of microbial activity. This likely arises as a consequence of slowed passage, which impairs ability to

translocate indigenous bacteria down the digestive tract, resulting in intestinal overgrowth (Campbell *et al.*, 1983 c; Salih, 1986). It is well established that chicks fed barley or rye give a greater response to antibiotics than those fed wheat or corn. The capability of dietary antibiotics to restore growth to control levels may depend on the magnitude of the initial depression; thus, a minor depression may be completely overcome, whereas a more severe depression is not.

The severity of growth depression is also influenced by age, with the magnitude of the response lessening with advancing age (Salih, 1986). Feeding barley to older birds does not cause a reduction in feed transit time when compared to feeding wheat, despite significantly higher viscosity of intestinal contents. This ability in turn may affect the unstirred water layer, gut microflora and feed intake.

These effects will, of course, depend on the level of gum occurring in a particular grain sample. Factors affecting β -glucan in barley have been studied more extensively than pentosan in rye, due to the importance of the former to the brewing industry. β -glucan is known to be affected by both environmental conditions during growth, as well as plant breeding.

iii) Response of broiler chicks given high or low viscosity barley to dietary enzyme.

Environmentally, β -glucan is affected by conditions during the latter phases of plant growth. In particular, drought conditions tend to elevate both soluble and insoluble β -glucan deposition (Aastrup, 1979, Hesselman and Thomke, 1982). This complies with regional differences in feeding value of barley for poultry; American barleys from western regions have long been considered inferior to those from more eastern regions, which is thought to

reflect climatic influences on β -glucan level. A confounding factor in this relationship is the level of endogenous β -glucanase, which counteracts the β -glucan, and may well be higher under wetter growing conditions. β -glucanase may also be added to the diet, and results concur with reported geographic differences; namely, western barleys respond more so than eastern barleys (Willingham *et al.*, 1960).

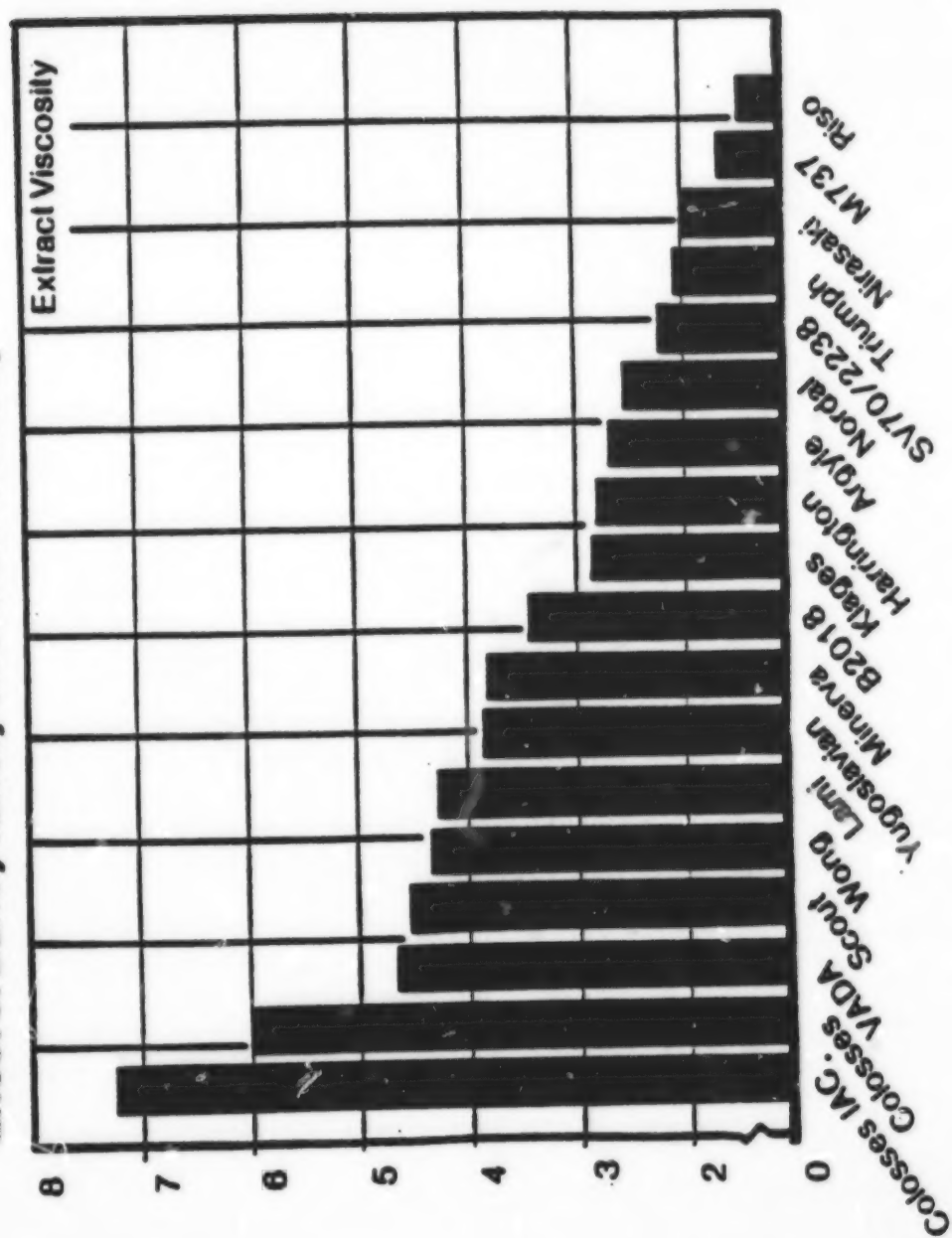
Western Canadian barleys may similarly vary in these characteristics, and if barley is to gain a stronger position in poultry diets it is crucial that we have a better understanding of the problem to address its solution; either by genetically lowering β -glucan through plant breeding, selecting barleys specifically for certain diets (as is presently done with malting barley) or supplementing diets with an appropriate enzyme. With regards to enzyme supplementation there is also the question as to whether selected diets should be supplemented, or whether enzyme should be added indiscriminately to all diets.

To address this question, sixty barley cultivars (including local and foreign samples) were screened for viscosity and β -glucan content (soluble and insoluble), and seventeen were selected representing high and low traits (B.G. Rossnagel, Crop Development Centre, University of Saskatchewan). These barleys were grown at five locations (Winnipeg, Brandon, Saskatoon, Lethbridge, and Beaverlodge) in Western Canada and then the grain was surveyed for viscosity of an acid buffer extract (which reflects soluble β -glucan), β -glucanase and crude protein.

The ranking of these barleys with respect to extract viscosity is shown in Figure 1. It is noteworthy that 'Scout', a hulless barley was among the highest tested, and consistently surpassed other commonly-grown Canadian

Figure 1.

Effect of Barley variety on extract viscosity



varieties in this regard. β -glucanase was not closely related to viscosity, but it tended to be higher among the 'low viscosity' barleys. Protein showed no relationship with viscosity type.

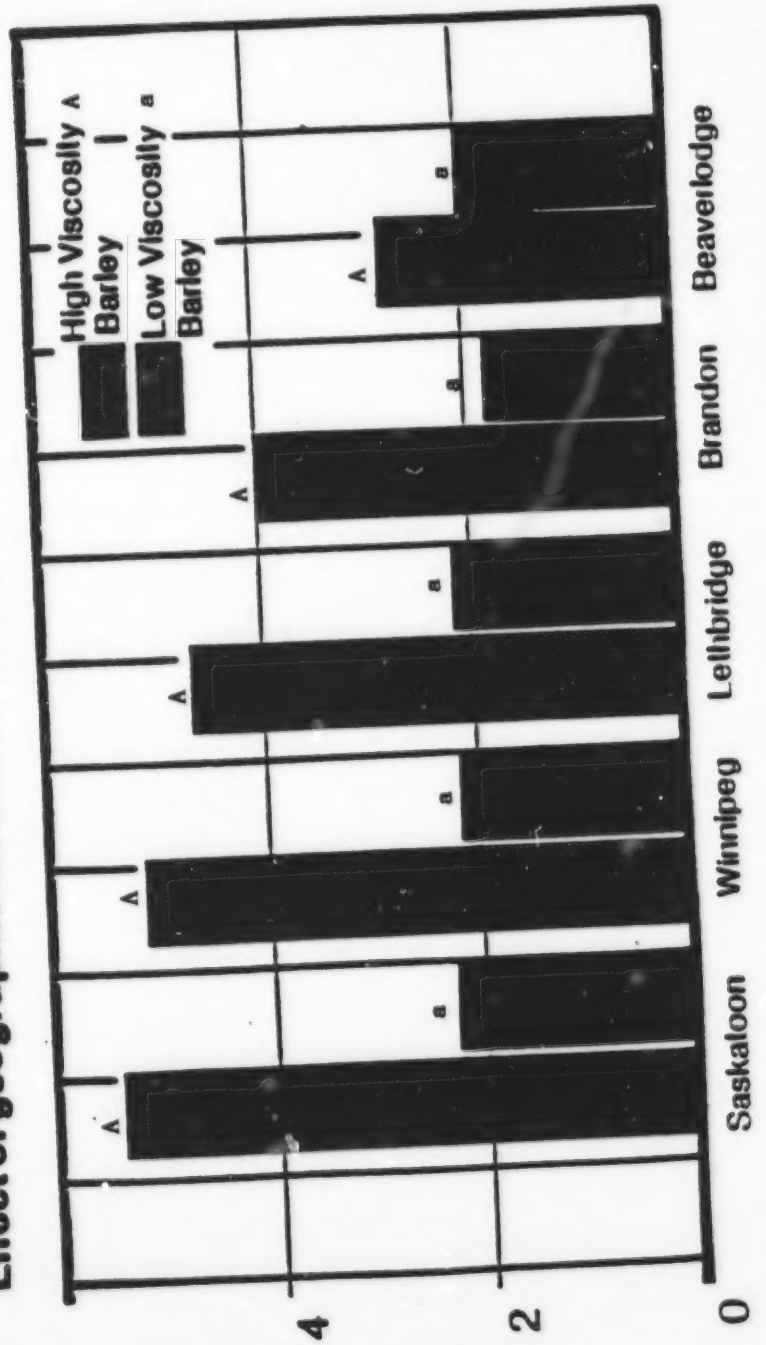
Location also impacted upon viscosity levels (Figure 2); however, this was only apparent for those barleys from the high viscosity grouping. Low viscosity barleys were uniform across locations. High viscosity barley grown in Beaverlodge, Alberta approached the low viscosity barleys, suggesting a north-south gradient in western Canada paralleling the east-west differences established for American barley. β -glucanase levels were again higher in low viscosity barleys, whereas protein was similar for the two barley types.

Any differences in viscosity may be offset by differences in endogenous β -glucanase level, again it has been proposed that this may relate to weather conditions. However, β -glucanase levels did not closely follow the pattern observed for viscosity. Possibly β -glucan is influenced by weather throughout the kernel filling and ripening process, whereas enzyme levels are dictated by conditions immediately prior to harvest. What is interesting is that high viscosity barleys tended to have lower levels of enzyme than low viscosity barleys, implying that problems induced by high viscosity may be compounded by low enzyme levels.

Agronomic practices will also influence extract viscosity of barleys. Hesselman *et al.*, (1981) observed a decline in extract viscosity from barley harvested at 'early yellow ripeness' as opposed to 'combine ripeness'. Classen *et al.*, (1987) observed an effect of seeding date (May 21 or June 14), fertilizer level and location (Melfort or Meath Park, Saskatchewan) on viscosity. Prolonging seeding date reduced viscosity, which may also be explained on the basis of delayed harvest.

Figure 2.

Effect of geographic location on extract viscosity



Of course, both β -glucan and β -glucanase levels would be irrelevant where there was no demonstrable effect in terms of animal performance. Two experiments conducted with broiler chicks illustrate the potential importance of viscosity in barley feeding value. In the first experiment, four high viscosity barleys were compared to four low types selected from barleys indicated in Figure 1. In terms of growth and feed conversion, the low viscosity types exceeded the high types in all cases (Table 1). One barley sample deserving comment is the Riso sample; despite the high fibre (and low bushel weight) character of this barley it still surpasses the high viscosity types for supporting chick growth.

Table 1. Performance of Broiler Chicks Fed High or Low Viscosity Barleys.¹

Low viscosity	Body Wt. (g)	Feed Conversion	High Viscosity	Body Wt. (g)	Feed Conversion
<u>Experiment 1</u>					
Triumph	404	1.61	Minerva	247	1.91
Nirasaki	387	1.57	Yugoslavian	255	1.82
Klages	391	1.66	Vada	255	1.94
Riso	343	1.70	Lami	316	1.72
<u>Experiment 2²</u>					
Triumph	449	1.56	Minerva	347	1.79
+enzyme	506	1.58	+enzyme	542	1.53
Nirasaki	435	1.63	Yugoslavian	339	1.84
+enzyme	525	1.50	+enzyme	519	1.55

¹ Body weight and feed conversion were significantly poorer for chicks fed the high viscosity barleys ($P < .05$).

² Enzyme addition significantly improved both body weight and feed conversion.

The second experiment involved supplementing both high and low viscosity barleys with dietary enzyme. With no enzyme, high viscosity barleys were clearly inferior to low viscosity types; yet with enzyme addition these differences were eliminated. One interesting result was the response of chicks fed low viscosity barley to enzyme. While not as great as that seen with high viscosity barley, the response was still substantial and sufficient to warrant enzyme addition to all diets containing barley.

Such responses certainly establish a rationale for adding β -glucanase to poultry feeds containing barley. A critical question is whether or not barley diets with enzyme can compete economically with conventional corn-based poultry diets. This will be a function of the performance obtained and the prevailing prices for barley versus other dietary energy and protein sources. Practical studies at the University of Saskatchewan have looked at enzyme supplementation of barley diets given to broiler chickens, laying hens, turkeys, and swine.

iv) Use of low density diets in poultry feeding programs.

Corn has long been the predominate cereal in animal feeds. The poultry industry, in particular, has demanded a high nutrient density diet that is difficult to achieve with a lower energy grain such as barley. As a result the nutrient requirements in poultry diets have generally been so high that they effectively exclude use of such ingredients as barley regardless of price. Clearly, where differences in the cost of ingredients are substantial some alterations in the biological performance of poultry can be accepted for the sake of overall efficiency.

One method of overcoming this situation is to formulate nutrient levels according to energy levels, thereby assuming that the chicken will manipulate

consumption to equalize nutrient intake regardless of diet density. When diet density is permitted to slide, the makeup of least-cost formulated diets will allow the use of barley, although the amount used will ultimately depend on ingredient costs. When barley is substituted for corn, less soybean meal is required as barley has a more favourable energy/protein ratio. When viewed per unit of nutritional equivalence barley is usually the better buy.

The argument for considering lower dietary density ultimately depends on the ability of the bird to increase consumption of lower energy diets in line with nutrient demands. This ability will vary with the nature of the poultry produced, as well as the ingredients selected.

3. PRACTICAL ASPECTS OF ENZYME-SUPPLEMENTATION OF BARLEY DIETS FOR POULTRY

1) Enzyme supplementation of barley diets for broiler chickens - university trials.

Several studies have been undertaken in which barley with an enzyme supplement was fed to broiler chickens raised to market weight. The most comprehensive of these trials considered nine barley samples collected from localities across Saskatchewan.

The first phase of the experiment established the need for the enzyme component in chicks raised to three weeks of age in battery brooders (Table 2). For all barleys tested, a substantial improvement was noted with enzyme addition. What is perhaps more important is the range of performance seen with or without enzyme addition. Without enzyme the range for chick body weight (345-467 g) was much greater than the same barleys with the enzyme (455-496 g). Likewise variation in feed conversion favoured the enzyme supplemented chicks (1.62-1.71) over their unsupplemented counterparts (1.63-

Table 2. Performance of Broilers Fed Diets Based on Saskatchewan Barleys With Enzyme Compared to a Standard Wheat-Corn Diet.

	Experiment 1 (to 3 wks)				Experiment 2 (to 6 wks)			
	Body Wt. (g)		Feed Conversion		Body Wt. (g)		Feed Conversion	
	-1	+1	-	+	3 wk	6 wk	3 wk	6 wk
Hector	398 ^{cd}	445 ^a	1.77 ^{abc}	1.65 ^a	484 ^{bc}	1702 ^c	1.75 ^{ab}	2.06 ^{ab}
Bedford	452 ^{ab}	463 ^a	1.63 ^{bc}	1.64 ^a	507 ^{bc}	1750 ^{bc}	1.73 ^{ab}	2.01 ^b
Diamond	345 ^d	457 ^a	1.85 ^a	1.71 ^a	540 ^{ab}	1764 ^{bc}	1.76 ^{ab}	2.11 ^a
Harrington	363 ^{cd}	476 ^a	1.82 ^{abc}	1.65 ^a	507 ^{bc}	1704 ^c	1.68 ^{ab}	2.01 ^b
Johnston	351 ^d	466 ^a	1.88 ^a	1.67 ^a	495 ^{bc}	1723 ^{bc}	1.74 ^{ab}	2.03 ^{ab}
Klages	447 ^{ab}	472 ^a	1.65 ^{bc}	1.62 ^a	492 ^{bc}	1717 ^c	1.76 ^a	2.08 ^{ab}
Leduc	457 ^{ab}	496 ^a	1.69 ^{abc}	1.58 ^a	543 ^{ab}	1779 ^b	1.63 ^{ab}	1.95 ^c
Norbert	467 ^{ab}	484 ^a	1.68 ^{abc}	1.57 ^a	542 ^{ab}	1755 ^{bc}	1.72 ^{ab}	2.10 ^a
Otal	435 ^{abc}	459 ^a	1.73 ^{abc}	1.70 ^a	520 ^{bc}	1710 ^c	1.71 ^{ab}	2.07 ^{ab}
X (all) (barley)	(413)	(469)	(1.74)	(1.64)	(514)	(1734)	(1.72)	(2.05)
Wheat-corn	520 ^a	501 ^a	1.61 ^{bc}	1.58 ^a	575 ^a	1821 ^a	1.57 ^b	1.93 ^c
S.E.M.	±21	±16	±.05	±.03	±10	±38	±.04	±.02

abc superscripts denote significant differences within a column. Analysis of variance indicated a significant response to enzyme for barley in Experiment 1.

1 With(+) and without(-) enzyme. All diets in Experiment 2 contained enzyme.

1.88). Thus enzyme addition to diets containing barley not only improved performance of broilers fed barley, but also reduced the variability among barley samples. The latter effect increases the accuracy of formulating barley rations and also reduces the risk of unpredictable results due to a poor barley sample.

When the same barleys were fed with enzyme to broilers finished to market weight, three week body weight was larger. This is probably due to the diet form which was mash in Experiment 1 and crumbles in Experiment 2.

Nevertheless the relative comparison to the wheat-corn based diet was much the same; in both cases the wheat-corn fed birds surpassed those fed barley by about 50g. The treatment differences at this stage did not differ greatly from those at the termination of the trial (70-80g); which represents an extension of time to achieve the same body weight of slightly over one day. This concurs with earlier results (Campbell *et al.*, 1984), in which barley diets without enzyme prolonged days-to-market by 4-5 days, and enzyme addition reduced this effect to 1.5 days (Table 3). The barley diets in this experiment were considerably lower in nutrient density as reflected in feed conversion. While feed conversion is important, similar days-to-market make direct comparisons on a cost basis possible. In this trial differences in ingredient prices heavily favoured the barley plus enzyme diets.

Table 3. Performance of male broilers fed diets based on wheat corn, barley, or barley and enzyme.

	Body weight (kg)		Feed intake (kg)		Feed conversion (F/G)			Feed cost to 1.8 kg body wt.
	4 wks	6 wks	0-4 wks	0-6 wks	0-4 wks	0-6 wks	1.8 kg	
Wheat	1.068	1.996	1.069	3.484	1.50	1.75	1.71	0.81
Barley	.866	1.718	1.506	3.530	1.73	2.05	2.08	0.73
Barley & Enzyme	1.045	1.891	1.748	3.738	1.67	1.99	1.96	0.70

While results comparing barley with enzyme diets show a slight superiority in favour of a diet containing corn in growth rate, comparisons with a straight wheat diet (Table 4) indicated those fed barley with enzyme were fully capable of overcoming nutrient density differences, and body weight

Table 4. Performance of broilers fed diets based on barley and wheat at varying nutrient densities.

Grain	Nutrient density	Body weight at 6 wks (kg)	Feed conversion (F/G)
Wheat	High - 3100 ¹	1.700	2.08
Wheat/Barley	Medium - 2900	1.754	2.15
Barley	Low - 2700	1.797	2.27

¹ Dietary ME, kcal/kg.

actually surpassed broilers fed the wheat diet (Kurulak, 1987).

The preceding discussion is based on experiments in which no effort was made to compare barley versus wheat and corn on an equivalent density basis; thus differences between grains are confounded by different energy and protein levels. If concentrated energy sources are available at reasonable cost it may be feasible to increase the energy density of barley-based diets near that of corn diets. When this was done, there was no clear differences in body weight at 6 weeks according to density or grain type (Table 5). Feed conversion also did not differ markedly from other diets at an equivalent density. To a large extent, differences with barley diets are not directly attributable to grain differences per se, but rather diet density.

In summary, barley diets with enzyme may be given to broilers with only minor delay in time required to reach market weight, usually 1-2 days when compared to a corn or a corn-wheat diet. Broilers fed barley with enzyme were able to sustain growth at an equivalent or superior level to those fed wheat in two experiments. Feed conversion was consistently somewhat poorer for broilers fed the barley diets, however these differences too were largely

Table 5. Performance of broilers fed diets based on barley, wheat and corn at varying nutrient densities.

Grain	Nutrient Density	Body weight at 6 weeks (kg)	Feed conversion (F/G)
Barley	High - 3000 ¹	1.754	1.97
Barley	Medium - 2900	1.703	2.01
Barley	Low - 2700	1.722	2.08
Wheat	High - 3100	1.666	1.95
Wheat/Barley	Medium - 2900	1.711	2.01
Corn	High - 3100	1.799	1.89
Corn/Barley	Medium - 2900	1.834	2.00

¹ Dietary ME, kcal/kg.

eliminated when diets were formulated on an equivalent density basis. Whether this approach is economical will be determined by local ingredient costs.

11) Enzyme supplementation of barley diets for broiler chickens - field study results.

Three field trials designed to demonstrate the feasibility of feeding low density barley broiler diets with an enzyme supplement are reported. The barley diets were manufactured by a local feed company and were compared to that firm's standard broiler feed. The trials are identified as Kruger, Milnel and Milne² and utilized approximately 20706, 9180 and 9180 broilers respectively for each diet. All diets were fed as crumbles and the composition and nutrient specifications for the barley diets are shown in Tables 6 and 7.

Table 6. Composition (%) of barley based broiler diets in Field Study Number 1

	<u>Starter</u>	<u>Grower</u>	<u>Finisher</u>
Barley	63.1	74.9	80.7
Soybean Meal (47% crude protein)	24.6	12.8	7.2
Limestone	.22	-	.20
Meat meal	7.10	7.27	7.19
Tallow	3.69	3.63	3.60
Dicalcium phosphate	.55	.38	.43
Salt	.24	.24	.21
L-lysine	-	.10	.09
DL-methionine	.11	.11	.13
Choline (60%)	.065	.060	.050
Coban 60 LT	.075	-	-
Coyden (25%)	-	.05	.05
Stafac (virginiamycin)	.05	.05	.05
Copper sulphate (25%)	.03	.03	-
Vitamin premix	.07	.07	.07
Mineral premix	.05	.05	.05
Endofeed (enzyme)	.025	.025	.025

Table 7. Recommended nutrient specifications for broiler chickens and the calculated nutrient levels of barley diets.

	<u>Broiler Starter</u> <u>(0-3 wks)</u>		<u>Broiler Grower</u> <u>(3-5 wks)</u>		<u>Broiler Finisher</u> <u>(5 wks +)</u>	
<u>Nutrient</u>	<u>NRC¹</u>	<u>Barley²</u>	<u>NRC</u>	<u>Barley</u>	<u>NRC</u>	<u>Barley</u>
Metabolizable energy (kcal/kg)	3200	2833	3200	2867	3200	2880
Crude protein (%)	23.0	22.0	20.0	18.2	18.0	16.2
Methionine (%)	.50	.46	.38	.39	.32	.36
Methionine and cystine (%)	.93	.79	.72	.69	.60	.65
Lysine (%)	1.20	1.20	1.00	1.06	.85	.90
Calcium (%)	1.00	.92	.90	.86	.80	.81
Total phosphorous (%)	.60 ³	.55	.55 ³	.50	.50 ³	.50
Sodium (%)	.15	.17	.15	.17	.15	.16

¹ Nutrient Requirements of Poultry, Eighth Revised Edition, 1984. National Research Council, National Academy Press, Washington, DC.

² Calculated value.

³ Estimated value.

Broilers were sample weighed at weekly intervals until time of slaughter (ranged from 41 to 44 days of age). The procedure consisted of randomly catching and weighing at least 20 broilers in each of 4 barn locations or a total of 80 broilers per diet or barn. Mortality was recorded on a daily basis and roughly sub-divided according to cause by the producer. Feed consumption was based on feed deliveries and feed remaining at trial end.

Growth of the broilers in all trials was quite good and was close to values published in the most recent Arbor Acres management guide (Table 8).

Table 8. Body weights (kg) of broilers fed a barley (B) or commercial (C) diet

Age, Days	Arbor Acres	KRUGER		MILNE1		MILNE2	
		B	C	B	C	B	C
7	.146 ¹	.129	.124	.145	.131	----	----
14	.363	.314	.324	.334	.316	.310	.364
21	.658	.622	.643	.653	.654	.594	.673
28	1.016	.976	1.043	1.020	1.070	.955	1.073
35	1.424	1.395	1.483	1.460	1.498	1.457	1.496
41				1.885	1.946		
				(1.733) ²	(1.795) ²	(1.722) ²	(1.845) ²
42	1.863	1.905	1.880				
43			(1.814) ²				
44		(1.839) ²					
42 <u>ESTIMATE</u>		1.714 ³	1.751 ³	1.796 ³	1.858 ³	1.785	1.908
*		+ .7		+ 1.0		+ 2.0	
Feed/Gain Ratio		2.333	2.083	2.255	2.052	2.153	2.061
Mortality		4.8%	4.4%	6.2%	7.3%	4.4%	6.5% ⁴

* Additional time to achieve some body weight (days).

¹ Liveweight based on a 80 bird sample.

² Liveweight just prior to slaughtering and after shrinkage has occurred. Based on all birds marketed.

³ Liveweight after shrinkage at 42 days of age estimated from the final market weight and a correction factor of .0627 kg per day (Arbor Acres).

⁴ Higher mortality due to heat stress in one barn.

Little difference in growth occurred between the low density barley fed chickens and the broilers fed the commercial control with final estimated 42 day bodyweight differences of .037 and .062 kg for the Kruger and Milne1 trials, respectively. According to the Arbor Acres guide, broilers are growing at approximately .0627 kg per day at this age and therefore the barley and enzyme fed birds would require approximately one half to one day to meet the same bodyweight as the broilers fed the commercial diet. The slightly larger difference in final body weight in Milne1 may represent a protein rather than a barley effect as the grower diet contained only 16.5% protein compared to 22.5% for the commercial grower (analyzed values). Growth of broilers fed barley in the Milne2 trial was further behind the control diet (2 days), although growth compared favorably with that of broilers given barley in the first two trials. It was established that enzyme levels were low in the starter diets due to enzyme loss from pelleting at 87°C, which is beyond the temperature stability of the enzyme. The birds did manage to overcome to some extent the initial growth depression by trial end.

Feed consumption increased with barley feeding because of the lower nutrient density (Table 9). The net result were higher feed to gain ratios but the values were close to expected based on energy values of the barley diets and estimated values for the commercial feeding program. However, the feed conversion for broilers given barley in the Milne2 trial was better than would be anticipated. Because of trade confidentiality, the exact energy contents of the commercial diets are not known.

Mortality was similar for both feeding programs, except for Milne2 trial, in which mortality was higher for the commercial diet. This was due to heat stress, and unrelated to treatment. Differences in litter condition were

Table 9. Feed consumption (tonnes) of birds fed barley or conventional broiler diets.

Diet	Starter	Grower	Finisher	Total
<u>Kruger</u> (20706 broilers per diet)				
Barley	21.055	42.785	19.905	83.745
Commercial	21.235	53.601	--	74.836
<u>Milnel</u> (9180 broilers per diet)				
Barley	6.980	26.840	--	33.820
Commercial	7.065	24.499	--	31.564
<u>Milne2</u> (9180 broilers per diet)				
Barley	10.980	21.550	--	32.530
Commercial	11.885	20.745	--	32.630

noted for the feeding programs. Barley feeding produced slightly wetter litter; it was not the problem of excessive stickiness noted when barley is fed without enzyme supplementation but there was evidence of caking in areas where birds tend to congregate. It should be noted that fecal volume will be higher with lower nutrient density diets, which alone could account for some difference.

In conclusion, feeding barley based diets of low nutrient density to broiler chickens resulted in a slight reduction in growth rate and a feed to gain ration which reflected the energy content of the diet.

Although performance of broilers given dietary enzyme in conjunction with broiler diets tends to be greatest in the starter phase, it is beneficial to also include it in finisher diets, if only to control litter wetness (Gohl *et al.*, 1978) and possible management problems.

iii) Enzyme supplementation of barley diets for laying hens.

The ability of birds to increase consumption of feeds with lower energy levels is paramount for effective use of barley in poultry diets. While the physical volume of a ration may limit feed intake by younger birds, research results indicate that laying hens respond favourably to barley. Campbell (1984) reviewed results from several experiments in which barley, wheat, and corn in laying hen diets were evaluated over a complete laying cycle. Egg production of laying hens fed low density barley diets compared very favourably to those fed wheat or corn. These data can be interpreted as positive evidence that the laying hens are able to increase consumption commensurate with energy demands.

In view of the diminishing effects of gums with age, it is not surprising that their role in laying hen production is minimal. Naturally, where there is little problem to correct, it is not likely that any substantial benefit will ensue from adding enzyme to the diet.

One laying hen trial conducted at the University of Saskatchewan involved feeding hens wheat, barley, or hulless barley as the sole cereal grain source (Table 10). In this trial, conventional barley fed hens surpassed the wheat fed hens in egg production while birds fed hulless barley were intermediate. Feed conversion for hens given barley was poorer than that for those given wheat; whereas hulless barley was significantly superior. A possible explanation for the poorer performance for hens given wheat relates to body weight; which were higher than for those fed conventional barley. However it should be noted that weight gain for hulless barley fed hens was as high as for the hens fed wheat.

Table 10. Performance of Laying Hens Fed Wheat, Barley, or Hulless Barley With or Without Enzyme.

<u>Cereal</u>	<u>Production (%)</u>	<u>Conversion¹</u>	<u>Body wt. gain (g)</u>	<u>Mortality (%)</u>
Wheat	86.8 ^b	1.60 ^b	407 ^a	6.3 ^a
Barley	88.5 ^a	1.66 ^a	293 ^b	5.1 ^a
Hulless Barley	87.3 ^{ab}	1.52 ^c	408 ^a	9.7 ^a
<u>Enzyme Level (%)</u>				
0	86.5	1.561	360	10.9
.0125	87.2	1.599	372	7.1
.0250	88.2	1.604	378	5.4
.0500	88.2	1.602	364	4.6
	(S) ²	(NS)	(NS)	(S)

¹ Feed per dozen eggs.

² Significant (S) or non-significant (NS) refers to regression analysis with enzyme level.

Given the excellent results obtained with the barley diets, it would be anticipated that the response to enzyme would be slight. This was the case, enzyme improved egg production, but only marginally. Also, the improvement was not limited to the barley diets, but occurred with hens given wheat as well. Again, this contradicts the viscosity factor as being solely responsible for the noted improvement. With such positive results even in the absence of enzyme it is difficult to comprehend why barley is not used more extensively in laying hen diets.

The preceding discussion provides a basis by which barley may be rationally used in diets for laying hens. In view of the feed consumption limitations of the hen in the early part of the production cycle, it may be wise to monitor weight gain during this period, and base barley level on weight. Since hens will normally sacrifice body weight gain and egg size

prior to reducing egg production, any drop in egg production should be forewarned by low body weight.

Two other approaches to increase energy intake in laying diets are to increase the density, particularly in the early phase, and to consider pelleting the diet. Increasing the density by addition of tallow may improve weight gain during initial phases of production (Campbell, 1986). Pelleting the diet will also increase consumption and nutrient intake in a similar manner. In fact, commercial egg laying diets are often pelleted in Western Canada. The decision to implement these alternatives should be based on the ability of the hens to achieve target body weight. Otherwise both may represent additional, perhaps unnecessary, costs.

A recent field study confirmed the use of barley for laying hens. Approximately 9,000 fifty three week old Dekalb hens were switched from a diet consisting of 52% wheat, 18% barley and 30% supplement (33% crude protein, vitamins, minerals) to one where all the grain component of the diet (70%) consisted of barley. The hens were laying at 85.5% (hen-day production) at the beginning of the seven week trial and remained above the standard Dekalb egg production curve throughout. In addition to no effect of feeding barley on egg production, no observable differences in egg quality were noted. No information was available on feed intake but presumably it would have gone up as a result of the lower energy of barley compared to wheat. The results support the use of barley in diets of high performing laying hens.

iv) Enzyme supplementation of barley diets for turkeys.

Several trials have been conducted where both hullless and conventional barley diets were fed to turkeys with and without dietary enzyme (Salmon *et al.*, 1986). Table 11 shows the results of an experiment with conventional

Table 11. β -glucanase Enzyme in Turkey Starter Diets to 4 weeks¹

Grain	-	Enzyme	+
<u>Liveweight, kg</u>			
Wheat	1.13		1.10
Barley	.83		1.09
<u>Feed intake, kg</u>			
Wheat	1.53		1.46
Barley	1.32		1.49
<u>Feed Efficiency (gain/feed)</u>			
Wheat	.71		.72
Barley	.59		.70

¹ Cereal and interaction effects were significant in each case ($P < .01$ and $P < .05$, respectively).

barley. In general, turkeys gave a similar response to broiler chickens, although it was less pronounced. The response was also greater for turkeys fed hulless barley over conventional barley. As occurs with chickens, the effect was most evident during the first four weeks, with less benefit seen in older birds. However, in one experiment, turkeys given the enzyme had a 3 to 5% improvement in feed conversion during the grower period, as well as a 6% improvement in final liveweights. Carcass grades as judged by finish or fat content, were also improved from 85 to 95% Grade A in this trial. Salmon *et al.*, (1986) also noted obvious improvements in litter condition among turkeys fed the enzyme-supplemented barley diets over their non-supplemented counterparts. They concluded that enzyme supplementation of barley diets for turkeys appeared a cost effective practice.

4. CONCLUSIONS

From a nutrition standpoint, barley provides an excellent cereal source for animal production - its protein content is significantly higher than corn, and its amino acid balance is better than wheat. Lower energy content, due to adherence of fibrous hull to the kernel, may be overcome by higher feed consumption. In older birds, this poses no difficulty; in young birds consumption and digestibility may be enhanced by dietary supplementation with an enzyme (β -glucanase) source. Extensive testing has shown that with appropriate treatment, barley may be used in all phases of poultry production.

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FINAL REPORT 1987-1988

July, 1988
~~MARCH 17~~

'FURTHER STUDIES ON ENZYMATIC IMPROVEMENT OF SASKATCHEWAN GROWN FEEDSTUFFS'

ADF CONTRACT R-86-01-0168

PRINCIPAL INVESTIGATOR

H.L. Classen

CO-INVESTIGATOR

G.L. Campbell

STATED OBJECTIVES:

- 1) To determine the apparent metabolizable energy (ME) of enzyme supplemented barley. To include i) comparison of the ME of barley with and without enzyme supplementation, ii) evaluation of pre-experiment feeding or the ME value of barley with or without enzyme supplementation, iii) characterization of the ME of a number of Saskatchewan barley samples of known cultivar and area of production.
- 2) To field test use of enzyme-supplemented barley diets for broiler chickens and laying hens.

(A) **EXECUTIVE SUMMARY**

ABSTRACT: Supplementing barley diets intended for poultry with a fungal enzyme capable of degrading polysaccharide gums (β -glucan) occurring in barley greatly improves its feeding value, however the improvement in terms of available energy (ME) is required for application of barley-enzyme diets. The ME of barley was substantially higher with enzyme inclusion in the diet. The ME for barley samples collected across Saskatchewan with enzyme supplementation was approximately 10 per cent below wheat. Since the barley seed is 10 per cent hull, this represents essentially complete utilization of the barley kernel. Feeding trials with local producers have shown barley to be an economical alternative to wheat and corn in broiler and laying hen diets.

SUMMARY: Poultry research in nutrition at the University of Saskatchewan has been directed towards the end objective of increasing utilization of Saskatchewan feed grains by the poultry industry, both in Canada and internationally. Major factor limiting barley use is polysaccharide gum, β -glucan, originating from the endosperm cell wall. This material solubilizes upon contact with digestive secretions, and because of its hygroscopic, sticky nature depresses nutrient assimilation. Fortunately, this problem may be conveniently dealt with by supplementing the diet with an enzyme (β -glucanase), that effectively reduces digesta viscosity and related problems. While the effectiveness of β -glucanase supplementation is conclusively established, industry requires quantification of the response to economically evaluate barely diets in comparison with conventional poultry diets. Perhaps the most important component of this concerns energy availability in various feeding situations. The present study demonstrated that enzyme supplementation eliminated the need for restrictions or level of barley in the diet from an energy-availability standpoint, and concerns regarding switching from one grain to another. The metabolizable energy of barleys collected from across Saskatchewan were approximately 10 per cent below wheat, which may be accounted for by the indigestible hull of barley, which also constitutes about 10% of the kernel.

Feeding trials with the co-operation of local producers and feed companies demonstrated that barley diets with enzyme could be successfully fed to both laying hens and a broiler chickens. There was no apparent loss of egg production (20,000 flock) in the laying hen operation when barley made up the entire cereal source. In the case of broiler chickens (40,000), barley fed broilers required on average, 1.3 days longer to achieve the same body weight (1.8 kg) on a 42 day production cycle than broilers given a commercial diet. This is not considered a major difference in performance level.

The experience gained in this research is being used in parallel research in several countries, with the participation of the Canadian Wheat Board, to evaluate the potential of barley use in their feeding programs. Successful penetration of the poultry market has the potential of substantially increasing the market for feed barley internationally. The poultry industry commands 60-70% of the feed grain trade. Locally, greater use of barley may reduce feed costs and improve the competitiveness of Canadian industry with their American counterparts.

(B) TECHNICAL REPORT

(Please note that the organization of the technical report is according to stated objectives rather than format suggested due to the diversity of the experiments).

ABSTRACT: The metabolizable energy (ME) of Saskatchewan barley was determined as affected by dietary β -glucanase, dietary pre-treatment (wheat or barley), level of dietary inclusion, diet form (mash or crumbles), and barley variety. The ME of barley was substantially higher when supplemented with the dietary enzyme for both hulled and hullless barley. The ME of wheat was also higher with the enzyme supplement. The ME of barley was not affected by dietary inclusion level or the pre-treatment diet in the presence of enzyme. In contrast to this, high barley levels or a barley pre-treatment diet depressed ME values in the absence of the enzyme. The ME values for barley collected from across Saskatchewan were 91% those observed for wheat in mash diets, which declined to 87% in crumbled diets. Feeding trials in co-operation with local feed producers demonstrated barley to be a viable alternative to wheat in broiler chicken and laying hen diets.

RESEARCH OBJECTIVE 1: Comparison of apparent metabolizable energy of barley fed with or without enzyme addition.

EXPERIMENTAL PROCEDURE: The ME of two barley samples ('Scout' and 'Minerva') were determined for three dietary inclusion levels (20, 40, or 60 per cent of the diet). Both varieties are considered high β -glucan barleys; they differ in that 'Scout' is hullless whereas 'Minerva' is a conventional hulled variety.

RESULTS: The results (Table 1) indicated that both barleys gave a substantial improvement in ME with inclusion of the enzyme, regardless of the barley level in the diet. In the unsupplemented diets the ME of Scout barley was higher at the lowest inclusion level (2675 kcal/kg) suggesting the possibility that the requirement for the enzyme was reduced at lower inclusion levels. However, this was not borne out with the 'Minerva'

sample - here there was no evidence of reduced enzyme requirement at lower inclusion levels. Interestingly, in this study the ME value of wheat also responded to the enzyme-supplementation (Table 2).

CONCLUSION: It was concluded that utilization of barley in the diet of young chicks was enhanced by enzyme supplementation, regardless of inclusion level. With enzyme addition to the diet, the ME of hulless barley approached that of wheat (98%).

Table 1. Effect of level of barley inclusion and enzyme supplementation on the ME of Scout and Minerva barley

Level barley inclusion (%)	Scout		Minerva	
	-1	+	-1	+
20	2581 (86.0) ¹	2905 (96.8)	1863 (12.1)	2974 (99.1)
40	2104 (70.1)	2985 (99.5)	1910 (63.7)	2636 (87.9)
60	2079 (69.3)	2930 (97.7)	1928 (64.3)	2656 (88.5)
MEAN	2255 (75.2)	2940 (98.0)	1900 (63.3)	2755 (91.8)

¹ Percentage of the ME of hard red spring wheat. Barley values based on a wheat ME of 3000 kcal/kg (air dry basis). Barley and enzyme effect are highly significant ($P < .01$).

RESEARCH OBJECTIVE 2: Evaluation of pre-experimental feeding on the subsequent ME of barley ('Scout')

EXPERIMENTAL PROCEDURE: Results from earlier experiments have suggested that the ME of a high B-glucan barley may be affected by the diet prior to ME determination, with the observed ME for barley being higher if fed following a wheat diet rather than continuous feeding of barley. This might be expected if the B-glucan were having a physiological effect as apposed to simply an immediate effect on digestibility. In practical terms, it raises the question that ME may be unpredictable over an extended feeding trial.

RESULTS: Some indication that this was occurring was evident from the experimental results in diets that were not enzyme supplemented (Table 3). With 'Scout' barley as the pre-treatment diet the observed ME was highest in the first collection period, and a decline was evident for periods two and three. With wheat as the pre-experimental diet, the observed ME for hulless barley without enzyme addition was consistently and substantially higher than when hulless barley constituted the pre-experiment diet.

Table 3. Effect of pre-treatment diet, collection period and enzyme addition on the ME of Scout barley

	Collection Period ¹			MEAN
	1	2	3	
<u>Scout barley pre-experiment diet</u>				
-	2370 (79.0) ²	1932 (64.4)	2022 (67.4)	2107 (70.2)
+	2835 (94.5)	2959 (98.6)	2936 (97.9)	2910 (97.0)
<u>Wheat pre-experiment diet</u>				
-	2509 (83.6)	2239 (74.6)	2147 (71.6)	2298 (76.6)
+	2859 (95.3)	3042 (101.4)	2950 (98.3)	2951 (98.4)

¹ 1 - 16 to 18 days of age; 2 - 19 to 21 days of age; 3 - 22 to 24 days of age. Enzyme effects were highly significant ($P < .01$). Pretreatment and collection period effects were near statistical significance.

² Percentage at the ME of hard red spring wheat. Barley values based on a wheat ME of 3000 kcal/kg (air dry basis).

In the presence of dietary enzyme, these differences were largely eliminated, although a slight trend in favor of the wheat experimental diet was evident.

Again, the overall ME of this particular hulless barley sample compared very favorably with the ME of wheat (94.5-101.4) when incorporated into diets containing enzyme.

RESEARCH OBJECTIVE 3: Evaluation of the ME of Saskatchewan barleys.

EXPERIMENTAL PROCEDURE: Barley samples representing typical Saskatchewan-grown varieties were collected from across Saskatchewan. All diets were supplemented with enzyme, and fed in diets as mash (ground, no heat treatment) or crumbled (crumbled following steam-pelleting).

RESULTS: The ME values, depicted in Table 4, indicated a lower ME in the crumbled diet. A depression of similar magnitude was evident for corn, which indicated this was a non-specific effect and not due to heat destruction of the enzyme material. Unlike the first 'Scout' sample studied, the ME of this particular sample was only average relative to other barleys, and substantially below that seen in the earlier study for hulless barley or wheat.

Effect of sample and form on the ME (kcal/kg) of barley

Sample	Mash	Crumble	MEAN
Hector	2842 (94.7) ¹	2653 (88.5)	2748
Bedford	2718 (87.4)	2604 (86.8)	2661
Klages	2760 (92.0)	2621 (87.4)	2691
Norbert	2914 (97.1)	2796 (93.2)	2855
Harrington	2629 (87.6)	2617 (87.2)	2623
Johnson	2612 (87.1)	2503 (83.4)	2558
Diamond	2629 (87.6)	2556 (85.2)	2593
Scout	2741 (91.4)	2622 (87.4)	2682
MEAN	2731 (91.0)	2622 (87.4)	2677

¹ Percentage of the ME of hard red spring wheat. Barley values based on a wheat ME of 3000 kcal/kg (air dry basis).

² Sample and form effects were highly significant ($P < .001$).

RESEARCH OBJECTIVE 4: For complete field study results please refer to enclosed documentation.

IMPACT ON SASKATCHEWAN AGRICULTURE

The results obtained in this research are being used in demonstration trials both in Western Canada and internationally. Success internationally would mean that buyers of Canadian barley could feed all livestock classes, including poultry, with a single cereal. This has the potential of substantially increasing the feed barley market at the expense of American corn. The international feed market, as a whole, is dominated by the poultry industry (60-70%). Greater use of barley in poultry diets locally could lower feed costs and improve competitiveness with the American poultry industry.

(C) PAPERS PREPARED: Enzyme Use in Barley Rations for Poultry. Prepared for Canadian International Grains Institute and the Canadian Wheat Board. 28 pp.

Invited lectures: Enzyme supplementation of barley diets for poultry (with Canadian Wheat Board and Canadian International Grains Institute).

Presented to:

1. Nehrung Import-Export, Leipzig, GDR.
2. Feed Barley Course, Saskatoon.
3. Philippines-Canada Grain Symposium, Saskatoon.
4. Korean Delegation, Saskatoon.
5. Bulgarian Delegation, Sophia, Bulgaria.
6. (Two similar courses slated for April and May, 1988).

- please refer to 'The Quarterly Bulletin' for further details.

(D) EXPENDITURES - attached.

(E) PERSONNEL INVOLVED - Time Involvement - G.L. Campbell - 25%
 - H.L. Classen - 10%

BARLEY-ENZYME USE IN BROILER CHICKEN DIETS

FIELD STUDIES

November 23, 1987

STUDY SITES:

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EXPERIMENTAL PROTOCOL:

Three field trials were designed to demonstrate the feasibility of feeding low density barley broiler diets with an enzyme supplement (Endofeed). The barley diets were manufactured by a local feed company and were compared to that firm's standard broiler feed. The trials are identified as Kruger, Milne1 and Milne2 and utilized approximately 20706, 9180 and 9180 broilers respectively for each diet. All diets were fed as crumbles and the composition and nutrient specifications for the barley diets are shown in Tables 1 and 2.

Broilers were sample weighed at weekly intervals until time of slaughter (ranged from 41 to 44 days of age). The procedure consisted of randomly catching and weighing at least 20 broilers in each of 4 barn locations or a total of 80 broilers per diet or barn. Mortality was recorded on a daily basis and roughly sub-divided according to cause by the producer. Feed consumption was based on feed deliveries and feed remaining at trial end.

RESULTS:

Growth of the broilers in all trials was quite good and was close to values published in the most recent Arbor Acres management guide (Table 3). Little difference in growth occurred between the low density barley fed chickens and the broilers fed the commercial control with final estimated 42 day bodyweight differences of .037 and .062 kg for the Kruger and Milne1 trials, respectively. According to the Arbor Acres guide, broilers are growing at approximately .0627 kg per day at this age and therefore the barley and enzyme fed birds would require approximately one half to one day to meet the same bodyweight as the broilers fed the commercial diet. The slightly larger difference in final body weight in Milne1 may represent a protein rather than a barley effect as the grower diet contained only 16.5% protein compared to 22.5% for the commercial grower (analyzed values). Growth of broilers fed barley in the Milne2 trial was further behind the control diet (2 days), although growth compared favorably with that of broilers given barley in the first two trials. It was established that enzyme levels were low in the starter diets due to enzyme loss during the starter phase. The pelleting temperature was 87°C, which is beyond the temperature stability of the enzyme. The birds did manage to overcome to some extent the initial growth depression by trial end.

Feed consumption increased with barley feeding because of the lower nutrient density (Table 4). The net result was higher feed to gain ratios but the values were close to expected based on energy values of the barley diets and estimated values for the commercial feeding program. However, the feed conversion for broilers given barley in the Milne2 trial was better than would be anticipated. Because of trade confidentiality, the exact energy contents of the commercial diets are not known.

Mortality was similar for both feeding programs, except for the Milne2 trial, in which mortality was higher for the commercial diet. This was due to heat stress, and unrelated to treatment. Differences in litter condition were noted for the feeding programs. Barley feeding produced slightly wetter litter; it was not the problem of excessive stickiness noted when barley is fed without enzyme supplementation but there was evidence of caking in areas where birds tend to congregate. It should be noted that fecal volume will be higher with lower nutrient density diets, which alone could account for the difference.

CONCLUSIONS:

Feeding barley based diets of low nutrient density to broiler chickens resulted in a slight reduction in growth rate and a feed to gain ration which reflected the energy content of the diet.

Table 1. Composition (%) of barley based broiler diets in Field Study Number 1

	Starter	Grower	Finisher
Barley	63.1	74.9	80.7
Soybean Meal (47% crude protein)	24.6	12.8	7.2
Limestone	.22	-	.20
Meat meal	7.10	7.27	7.19
Tallow	3.69	3.63	3.60
Dicalcium phosphate	.55	.38	.43
Salt	.24	.24	.21
L-lysine	-	.10	.09
DL-methionine	.11	.11	.13
Choline (60%)	.065	.060	.050
Coban 60 LT	.075	-	-
Coyden (25%)	-	.05	.05
Stafac (virginiamycin)	.05	.05	.05
Copper sulphate (25%)	.03	.03	-
Vitamin premix	.07	.07	.07
Mineral premix	.05	.05	.05
Endofeed (enzyme)	.025	.025	.025

Table 2. Recommended nutrient specifications for broiler chickens and the calculated nutrient levels of barley diets.

Nutrient	Broiler Starter (0-3 wks)		Broiler Grower (3-5 wks)		Broiler Finisher (5 wks +)	
	NRC ¹	Barley ²	NRC	Barley	NRC	Barley
Metabolizable energy (kcal/kg)	3200	2833	3200	2867	3200	2880
Crude protein (%)	23.0	22.0	20.0	18.2	18.0	16.2
Methionine (%)	.50	.46	.38	.39	.32	.36
Methionine and cystine (%)	.93	.79	.72	.69	.60	.65
Lysine (%)	1.20	1.20	1.00	1.06	.85	.90
Calcium (%)	1.00 ³	.92	.90	.86	.80 ³	.81
Total phosphorous (%)	.60 ³	.55	.55 ³	.50	.50 ³	.50
Sodium (%)	.15	.17	.15	.17	.15	.16

¹ Nutrient Requirements of Poultry, Eighth Revised Edition, 1984. National Research Council, National Academy Press, Washington, DC.

² Calculated value.

³ Estimated value.

Table 3. Body weights (kg) of broilers fed a barley or commercial diet

Age, Days	Arbor Acres	KRUGER		MILNE1		MILNE2	
		B	C	B	C	B	C
7	.146 ¹	.129	.124	.145	.131	—	—
14	.363	.314	.324	.334	.316	.310	.364
21	.658	.622	.643	.653	.654	.594	.673
28	1.016	.976	1.043	1.020	1.070	.955	1.073
35	1.424	1.395	1.483	1.460	1.498	1.457	1.496
41				1.885	1.946		
				(1.733) ²	(1.795) ²	(1.722)	(1.845)
42	1.863	1.905	1.880				
43			(1.814) ²				
44		(1.839) ²					
42	<u>ESTIMATE</u>	1.714 ³	1.751 ³	1.796 ³	1.858 ³	1.785	1.908
*		+ .7		+ 1.0		+ 2.0	
Feed/Gain Ratio		2.333	2.083	2.255	2.052	2.153	2.061
Mortality		4.8%	4.4%	6.2%	7.3%	4.4%	6.5% ⁴

- * Additional time to achieve some body weight (days).
- 1 Liveweight based on a 80 bird sample.
- 2 Liveweight just prior to slaughtering and after shrinkage has occurred. Based on all birds marketed.
- 3 Liveweight after shrinkage at 42 days of age estimated from the final market weight and a correction factor of .0627 kg per day (Arbor Acres).
- 4 Higher mortality due to heat stress in one barn.

Table 4. Feed consumption (tonnes) of birds fed barley or conventional broiler diets.

Diet	Starter	Grower	Finisher	Total
<u>Kruger</u> (20706 broilers per diet)				
Barley	21.055	42.785	19.905	83.745
Commercial	21.235	53.601	—	74.836
<u>Milnel</u> (9180 broilers per diet)				
Barley	6.980	26.840	—	33.820
Commercial	7.065	24.499	—	31.564
<u>Milne2</u> (9180 broilers per diet)				
Barley	10.980	21.550	—	32.530
Commercial	11.885	20.745	—	32.630

BARLEY-ENZYME USE IN LAYING HEN DIETS

FIELD STUDY

November 23, 1987

STUDY SITE:

Mr. Stan Fehr
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EXPERIMENTAL PROTOCOL:

One cage laying barn originally housing 9,000 Dekalb XL pullets was used to examine the effects of using barley and Endofeed (B-glucanase source) in laying hen diets. The hens were 54 weeks of age at the time the field study was started and were fed a "home mixed" combination of wheat, barley and 33% crude protein supplement (Table 1) in a mash form. Endofeed was added to the diet at a rate of 250 grams per tonne of complete layer ration and the barley level was increased in two steps with a week interval between changes to 70% of the total diet or the complete cereal grain component (Table 1). The 70% diet was then fed until the end of the field study or a total of 42 days. Egg production records were maintained on a daily basis throughout the study as well as egg cleanliness and quality.

RESULTS:

The egg production curve of the experimental flock is contrasted to the expected Dekalb XL production in Figure 1. The egg production for the experimental flock was excellent and above the Dekalb standards. Total replacement of the cereal grain portion of the diet with barley did not adversely affect egg production as the margin above the Dekalb XL curve was maintained for the entire study. No feed consumption records are available, but based on experimental data an increase in feed intake would occur due to the lower nutrient density of the barley diet. Throughout the experimental period no evidence of increased egg soiling was noted and there was also no obvious influence on other egg quality parameters. An interesting observation made by Mr. Fehr was that occasionally the 70% barley diet did not flow properly through the feeding system due to bridging in the bulk bin. This is undoubtedly due to the presence of the fibrous hull.

CONCLUSIONS:

The results of this study confirm experimental findings that barley can be used successfully as the entire cereal grain component of laying hen rations. The strength of this conclusion is increased by the very high level of production by the experimental hens and the commercial nature of the facility used in the test.

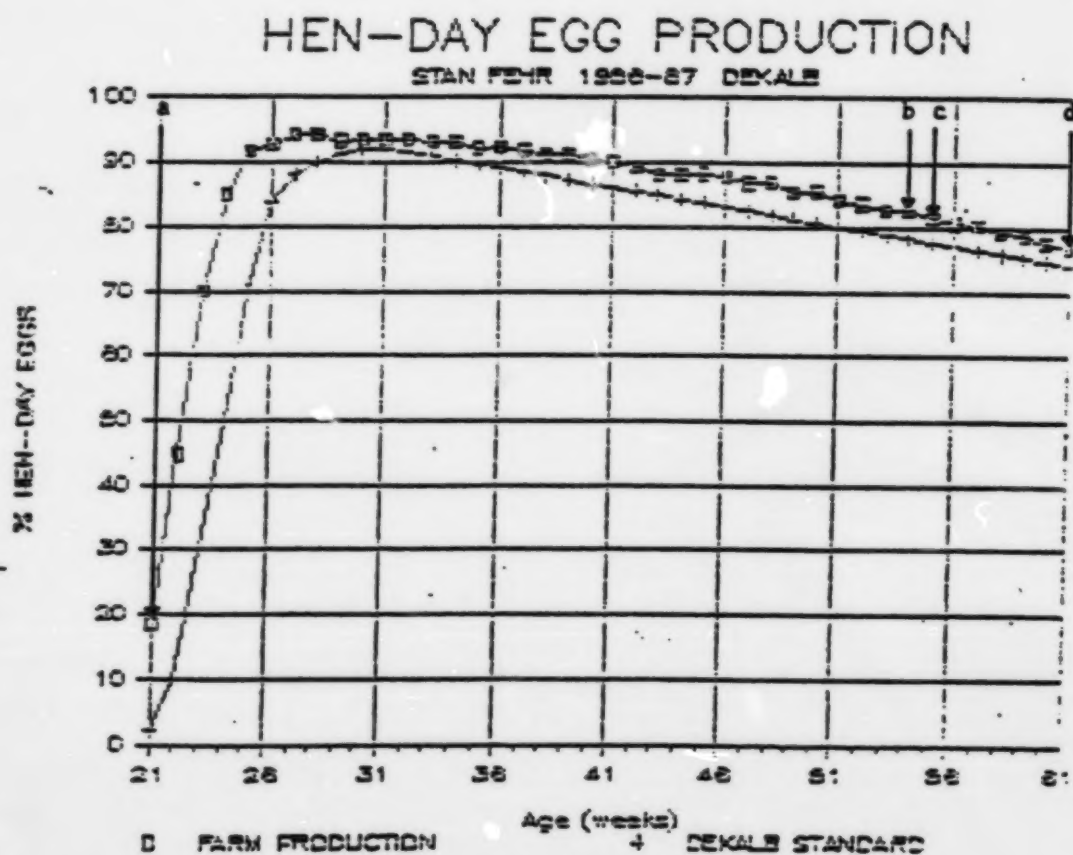
Table 1. Composition of laying hen diets and dates fed

Ingredients (%)	Diet		
	1	2	3
Wheat	52	26	0
Barley	18	44	70
Supplement ¹	30	30	30
Dates fed	8/12/87 ² to 3/28/87	3/29/87 to 4/4/87	4/5/87 to 5/16/87

¹ Contained 33% crude protein, minerals and vitamins.

² Pullets 20 weeks of age.

Figure 1



a - b Diet 1, b - c Diet 2, c - d Diet 3